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Proceedings of the Regional Peer Review: Interior Fraser River Coho Salmon Interim Assessment

January 23-24, 2014
February 14, 2014
Pacific Biological Station

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Editors: Mary Thiess and Lynda Ritchie

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting held on 23-24 January and 14 February 2014 at the Pacific Biological Station in Nanaimo, B.C. A working paper that assessed the Interior Fraser River Coho Salmon Management Unit relative to recovery objectives identified in a 2006 Conservation Strategy Recovery document was assessed by two external peer reviewers and meeting participants. Participants included current and retired DFO Science and Fisheries and Aquatic Management staff plus representatives from the Commercial Salmon Advisory Board, Marine Conservation Caucus, the US National Marine Fisheries Service, Sport Fishery Advisory Board, Okanagan Nation Alliance, Upper Fraser Fisheries Conservation Alliance, Northwest Indian Fisheries Commission, Pacific Salmon Foundation, Fraser River Aboriginal Fisheries Secretariat, Secwepemc Fisheries Commission, and the Okanagan Nation Alliance.

The results of this review will be provided in the form of a Science Advisory Report, a Research Document as well as these Proceedings; all of which will be made publicly available on the Canadian Science Advisory Secretariat website.

Compte rendu de la réunion régionale d'examen de l'Évaluation intérimaire du saumon coho du cours supérieur du Fraser

SOMMAIRE

Le présent compte rendu résume l'essentiel des discussions et conclusions de la réunion régionale d'examen par des pairs de Pêches et Océans Canada (MPO) et du Secrétariat canadien de consultation scientifique (SCCS) qui a eu lieu du 23 au 24 janvier, et le 14 février 2014 à la station biologique du Pacifique de Nanaimo, en C.-B. Un document de travail qui évaluait la zone de gestion du saumon coho du Fraser intérieur en rapport avec les objectifs de rétablissement indiqués dans un document de stratégie de conservation de 2006 a été évalué par deux pairs examinateurs externes et par des participants à la réunion. Parmi les participants se trouvaient des membres de Sciences et Gestion des pêches et de gestion des ressources aquatiques en poste et à la retraite ainsi que des représentants du Comité consultatif sur la pêche commerciale au saumon, du Comité de la conservation de la ressource maritime, du National Marine Fisheries Service des É.-U., du Conseil consultatif sur la pêche sportive, de l'Okanagan Nation Alliance, de la Upper Fraser Fisheries Conservation Alliance, de la Fondation du saumon du Pacifique, du Fraser River Aboriginal Fisheries Secretariat, et de la Secwepemc Fisheries Commission.

Les résultats de l'examen doivent être publiés sous forme d'avis scientifique, de document de recherche et du présent compte rendu, Tous ces documents seront rendus publics sur le site Web du Secrétariat canadien de consultation scientifique.

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer Review (RPR) meeting was held on January 23-24, 2014 at the Pacific Biological Station in Nanaimo to review an assessment of the interior Fraser River Coho Salmon management unit and additionally, to provide advice to Fisheries Management Branch (FM) with respect to the potential impact of increased Sockeye salmon harvest on this management unit. The assessment was revised in response to feedback at this meeting and a revised document was reviewed at a follow up meeting held February 14, 2014, also at the Pacific Biological Station in Nanaimo.

The following research document was prepared and made available to meeting participants prior to the meeting (a summary is provided in Appendix D):

Decker. A.S., Hawkshaw, M.A., Patten, B.A, Sawada, J, Jantz, A. L. 2014. Assessment of the Interior Fraser Coho Salmon *(Oncorhynchus kisutch)* Management Unit Relative to the 2006 Conservation Strategy Recovery Objectives. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/086. xi + 64 p.

The Chair, Jim Irvine, opened the January meeting by welcoming participants and reviewing general meeting logistics. The room was equipped with a conference phone and GoTo Meeting access to allow remote participation by web-based attendees, and in-person attendees were reminded to address comments and questions so they could be heard by those online. Additionally, the Chair requested that sidebar conversations or necessary phone calls be taken outside of the meeting room. A round of introductions followed, both in the room and among those online. The Chair then reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process, including the Scientific Advice for Government Effectiveness (SAGE) Principles. The Chair discussed the role of participants, the various publications that are expected to follow from this regional peer review (RPR) process (including a Science Advisory Report, Proceedings and a Research Document), and the definition of consensus, which would be required for the decisions and advice arising from the review. Everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice, based on the best available current knowledge.

The Chair reviewed the Terms of Reference (Appendix A) and Agenda (Appendix B) for the meeting, highlighting the objectives and expected outcomes of this review. The Chair emphasized that the review was not intended to discuss policy, social or economic considerations, but to review the data and information presented within the framework of the Terms of Reference. In total, 47 people participated in this RPR (Appendix F).

Participants were informed that Mary Thiess and Lynda Ritchie would be acting as co-rapporteurs for both days of the meeting. The Chair then introduced the reviewers, Dr. Mike Bradford (DFO) and Dr. Pete Lawson (NMFS). Both reviewers' comments were distributed to participants via the CSAP ftp site in advance of the meeting.

The co-authors presented an overview of the research document, Assessment of the Interior Fraser River Coho Salmon (*Oncorhynchus kisutch*) Management Unit Relative to the 2006 Conservation Strategy Recovery Objectives Decker et al (2014). There were no points of clarification raised during the working paper presentation, and any that arose following the presentation are included in the appropriate discussion section below.

QUESTIONS FOR CLARIFICATION FOLLOWING 23 JANUARY 2014 PRESENTATION OF THE WORKING PAPER

- Some questions and issues with figures (axes labels and interpretations) were addressed. The authors were asked to explain in greater detail the output figures from both the equilibrium trade-off curves and closed loop analyses. The authors were able to point out the salient features of each figure on-screen. The authors will need to ensure that figures are edited appropriately (e.g., in presentation slide 11, the authors need to shift exploitation time series to match x-axis. Note this figure was not in the working paper though.).
- The authors were asked if there was a reference to rigorous assessment of the time series method presented in the working paper. The authors indicated there was a published textbook outlining this method, but were unsure of the extent to which it had been tested.
- The authors were asked how hatchery fish had been treated in the Stock-Recruit (S-R) analysis. The authors indicated that, overall, the contribution of hatchery fish was assumed low enough not to be significant.
- It was pointed out that there were some inconsistencies among the values in Table 1. The authors will review Table 1 for accuracy and ensure the correct data was used in the modeling exercises.
- Committee members identified that Table 2 was taken from Fisheries Regulation Assessment Model (FRAM) but there was no discussion about the table found in the text.
- Fundamental Concerns with Analysis: equilibrium model results are very dependent on assumptions about productivities; need to be clear how extirpation is defined;
- Future work: It was suggested that future work include a refinement of pre-1986 exploitation rates based on the 1986-1998 base period (which is currently used to model exploitation post-1998).

PRESENTATION OF EXTERNAL REVIEWS

REVIEWER 1: PETE LAWSON

A copy of this review is included in Appendix D.

Overall, the reviewer felt the document was readable and there were no fundamental issues with the paper. The reviewer noted how the patterns being discussed here are remarkably similar to Oregon Coast Coho which would suggest that this is a coast wide, ocean driven pattern (i.e. an early period of high escapement and high harvest followed by decline in survival, a belated reduction in harvest rate and slow, partial recovery thereafter). The reviewer also presented a conceptual model, capturing productivity as a melding of larger oceanic trends such as PDO with declining freshwater survival, effectively an oscillation downward, that illustrated the need to consider longer term trends, rather than just short term patterns (Lawson 1993), and indicated that discussion of this concept would strengthen the paper. In Oregon PDO explains a lot of variability.

The strengths of the working paper, identified by the reviewer, included:

- the work was based on a wide variety of peer review work (with the exception of the three exploitation rate models);
- the authors applied a variety of models and analytic techniques;
- the working paper was clearly written;
- the authors drew initial estimates for model parameters from meta-analysis;

- the authors "ground truthed" results with other related stocks and analyses (the reviewer wondered if this may be a circular argument though); and,
- the authors acknowledged some of the limitations and biases of their work (but perhaps did not explain or explore in enough detail).

The reviewer also identified some weaknesses in the working paper, including:

- major data assumptions prior to 1998 (infilling 20 years of data is problematic because it assumes a constant relationship among CUs over time);
- assumes productivity is stationary (but time series analysis allows for regime changes);
- use of Ricker-based S-R analysis (there are known biases associated with this);
- equilibrium assumptions (which are related to stationarity assumptions). How does equilibrium relate to the current state (for a system that is never really in equilibrium)?; and,
- comparison of outputs to Skeena and Strait of Georgia meta-analyses may promote circularity. Not sure this is ground-truthing, May be a problem with suiting an expectation or cementing an expectation rather confirming the result.

With respect to recommended percentage of maximum sustainable yield (MSY), the reviewer approved the extent to which the proposed advice differed from previous guidelines given the lower productivity regime.(i.e., 20-30% of MSY being much lower—more precautionary—than past guidelines of 60-70% MSY).

The reviewer indicated that there is a need to understand freshwater survival independently from marine survival and that the working paper did not separate these two effects very well. (The authors could perhaps make use of the correlation between Pacific Decadal Oscillation (PDO) and longer term patterns or other results to better inform this aspect of the analysis.

A committee member clarified that the PDO cycle can also be correlated with freshwater survival, because it affects water yield and groundwater sources.

It was announced that authors' responses to reviewers would follow completion of both reviews.

REVIEWER 2: MIKE BRADFORD

A copy of this review is included in Appendix E.

The second reviewer echoed the sentiments of the first reviewer that the working paper was impressive given the time line available for completion. He also noted it was well-written and easy to understand (pending the above noted adjustments to brood tables, clarifications, etc.).

The reviewer then organized the remainder of his review with respect to the five objectives included in the Terms of Reference and suggested that specific comments in the paper's conclusions match the stated objectives. This was only partially fulfilled in the draft working paper.

- Objective 1: There was no update provided in the working paper on fishery management actions taken since 2006 (though this is not really a topic for advice). The reviewer suggested that the authors should consider providing an update to the information provided in Appendix 5 of the original IFCRT Conservation Strategy for Coho Salmon document (IFCRT 2006).
- Objective 2: The authors provided a good basis for the analysis they conducted. Ten years ago, the focus was on North and South Thompson time series because they provided the most complete data, but perhaps the current review could also focus on subpopulations which have a stronger time series now.

- Objective 3: The reviewer would like to have seen more commentary about how IFCRT objectives from 2006 were chosen for assessment. The original IFCRT objectives were defined along two axes: abundance and productivity. The reviewer did not feel the authors provided enough quantitative evidence to support IFCRT objective 2. Important that the productivity message be carried forward as part of the advice.
- Objective 4: The working paper says exploitation rates are biased, but then does not discuss the nature of the biases (e.g. perhaps the biases are not readily definable or quantifiable, but that at least needs to be recognized in the commentary). The authors should also attempt to discuss implications of potential biases/errors in estimation of exploitation, etc. Finally, the authors should also update the fisheries information presented. The reviewer also highlighted that new data on release mortality rates are available.
- Objective 5: The reviewer felt that this objective was not addressed in the working paper. The authors presented a number of simulation results, but did not frame them in terms of the original recovery objectives. Any rapid changes in productivity or survival were not tracked in the stock-recruit analysis (i.e. it uses time-averaged productivities). Simulations assuming constant exploitation and productivity rates are not going to be useful to assess management actions. The reviewer noted that system productivities change with abundance (small abundances focus in larger systems) and over time, so assuming average or time invariant productivity won't be relatable to what nature throws at us. Ricker averages response to productivity so at low years you will dip into your Coho bank or capitol. Science advice should not be based on simulated results of unrealistic scenarios. The authors did not demonstrate how well the autocorrelation model used to model productivity tracked historical results.
- There was no information provided on extinction in the working paper, but it was presented in the authors' presentation of the paper. Commonly, a threshold value of 100 fish (or 25 or 50) is used, but this needs to be explicitly defined in the text.
- Specific comments on conclusions: The reviewer would like to see the conclusions matched to the stated objectives. This was only partially fulfilled in the draft working paper.

There were no questions for clarification following this review.

AUTHORS' RESPONSES TO REVIEWERS

The authors addressed the issues of the lack of discussion around freshwater effects and potential for circular arguments noted by the first reviewer.

- Most freshwater Coho habitat occurs in ranching valleys where there has been no real change in recent periods and tree loss as a function of pine beetle has stabilized.
    - A member of the committee noted that the act of ranching valleys as well as pine beetle deforestation may have changed sensitivity of streams and rivers to changes in Pacific Decadal Oscillation (PDO), etc.
- The authors agreed it is important to parse out freshwater and marine survival effects. (Strait of Georgia wild Coho marine survival is used as the surrogate estimate of marine survival for Interior Fraser River Coho). There is correlation but it is not as fine-tuned as it could be.
- The authors also noted they used the best available data for their simulations. Recruit deviation values were modelled, but other results were based on separate data (so there is not a circular argument being presented here).
- Response to the second reviewers comments, based on the TOR objectives:

- Objective 1: The authors agreed to update the timeline originally presented in Appendix 5 in IFCRT conservation strategy.
- Objective 2: No revisions to working paper required.
- Objective 5: The authors acknowledged that there are problems with Ricker SR models based on short time series (because they are based on average conditions). The authors sought quantitative guidance from the reviewer on how to overcome this issue. One possibility posed that a link function between productivity and harvest function be added to the Ricker model. Another suggestion was to include a harvest control rule that is modelled on current observed productivity (rather than using average productivity of overall regime period). It was noted that there are problems estimating current productivity accurately and that harvest rules would not be straight forward to implement because instantaneous productivity is not the only consideration. For example if there is high productivity but low abundance, there would be no desire to increase harvest levels either. It was noted that this work is doable, but not in the current time frame for this process.
- The authors defended their use of the Ricker model versus other available choices (Beverton-Holt, hockey stick, power model). They felt it was justified to choose the Ricker model as they did, but perhaps did not discuss it fully enough in the paper. It was recommended that the underlying data be summarized in a plot or table so that readers could judge the model's suitability for themselves. It is challenging to fit models when there is periodicity in productivity and/or abundance. It gives the illusion of a stock recruit relationship when in fact, one does not exist. Interaction among time series is called aliasing. The authors should connect the data points in their productivity versus abundance plot to ensure the pattern is random. If there is a discernible pattern, then the authors would need to insure the density-dependent processes are being modelled appropriately. This issue was then parked for further discussion at a later point in the meeting.

GENERAL QUESTIONS & DISCUSSION

The group discussed whether the authors had addressed depensation or Allee effects sufficiently. Sound evidence exists to suggest there would be depensation effects at low spawner abundances (i.e., increasing vulnerability to local disturbances), but it was noted that modelling depensation is difficult. Evidence of depensation might be illustrated by incorporating the reviewer's suggestion to connect the points (chronologically) in the productivity versus spawners plot. The group emphasized that from a conservation perspective, the stocks being considered should not be allowed to get into a range where depensation is a factor. It was recommended that the authors consider adding some commentary about depensation to the working paper, and perhaps an appendix with lower limits of fish/km (based on information in the IFCRT recovery strategy). It was also suggested that an update of the original analysis of evidence for potential depensation could be added to the list of future considerations.

There was further discussion about what the revised productivity versus spawner plot could be used to illustrate. If the points connected chronologically showed a pattern of "circling in" over time, then that would indicate that the stock recruit models used in the analysis and simulation sections of the working paper are not appropriate.

The group then discussed the possibility of updating the simulation models to include adaptive harvest rates and implementation error (i.e., observation error), and indicated that the current model parameterization underestimates the actual uncertainty that exists. It was noted that

observation/management error can overwhelm any real differences in actual harvest rate. Any attempt to address these types of uncertainty will be better than ignoring them altogether.

The authors noted that a separate Wild Salmon Policy (WSP) status assessment is scheduled for completion later this year and that the current work was not intended to overlap with WSP benchmarks, but should be related to the conservation objectives given in the IFCRT recovery strategy.

The group then discussed the time frame for the advice being generated from this process. The working paper introduction indicated that the advice is intended to inform 2014 season planning. The group was unsure if the planning referred to is for next season or for longer term (i.e., over the next 10 years). In response, the authors clarified that their thinking was more generally "short term" than for any specific year.

Additional clarification regarding TOR objective 5 was required. Fisheries Management (FM) staff noted that the original request for advice (RFA) did not request an actual management strategy (e.g. annual versus fixed multi-year strategy). The fifth objective in the TOR was motivated by a figure from Bradford et al. (1998) showing isopleth bars on a freshwater survival versus marine survival plot. FM staff noted that there is not a lot of intensive in-season information to work with for these stocks, so the advice generated from this process could be used to derive harvest rules. It was also noted that the intent for this process was to at least discuss changes in harvest versus changes in productivity and to investigate strategies which might be more robust than others to these changes. Members of the group felt that the current analysis should be able to provide all the pieces needed to give a range of possible outcomes, dependent on a range of productivity and abundance scenarios. CSAP staff emphasized that the group (and the authors) needed to stick to the TOR. If there is potential to explain parts of the TOR better with further work, then that work could be included in the revisions. Otherwise, off-scope items and analyses can only be noted under future considerations.

The group then discussed spatial risks. Depending on harvest rates, the same subpopulations would be chronically affected by harvest rate changes; e.g. the model shows that the Upper Adams subpopulation would be adversely affected (but the authors note that it may also be underestimating escapement for this subpopulation). It was suggested that the authors should identify in the working paper which subpopulations are at greatest risk (i.e. exhibit the lowest productivity). In particular, members of the group wanted to know if the spatial risks were distributed evenly among the CUs, or if certain CUs were more at risk than others (because they contained the majority of subpopulations with lower productivities). The authors noted that they attempted a discussion of this topic at the end of section 2 in the working paper. The Fraser Canyon subpopulation is probably most at risk, the rest are spread somewhat evenly among the CUs. Lower Thompson subpopulations were identified as being the most chronically affected by changes in harvest rate though.

The group discussed what has happened to the Coho indicator stocks (crew can reliably visit 80-100 streams each year, so are less dependent on indicator stocks which also suffer from implementation issues such as cost, reliability, straying, etc.). It was also noted that Coho do not exhibit the same level of fidelity as other salmon species. It was also noted that, despite the problems with Coho indicator stocks, the current information being obtained has less uncertainties than past data. Authors used Strait of Georgia wild Coho survival rates to estimate Interior Fraser survival. With respect to the current marking rate of hatchery fish, there are not enough recoveries to get reasonable survival estimates (particularly when marine survival is low).

At this point, the group was encouraged to send minor revisions for the working paper directly to the authors.

The group discussed the sources of data for Table 1 and necessary updates required. The wild abundance reported in this table is wrong and the authors need to confirm whether it was limited to the table, or if the wrong data was also used in the simulation models. The table should also contain a column for Total Wild Return, separate from Total Return, so that readers can calculate the estimated hatchery contribution in each year. SEP staff noted that production of hatchery fish is decreasing but the marking rate is increasing. A component of unmarked hatchery fish still exists in the return though. Members of the group questioned how the marine survival rates reported in Table 1 were used in the analysis. The authors indicated that they were used in the split life stage analysis, but no recommendations are based on the results.

Members of the group expressed concern about some of the data, models and methods used in the simulation analysis. Many of them are not published in a form that can be independently accessed and assessed. When this data analysis is updated in the future, it means it will be difficult to replicate what has been done in this working paper. Some members of the group were not convinced that the models and methods have been tested as thoroughly as indicated in the working paper. The authors committed to publishing the model code and data (perhaps as an appendix in the current paper), along with commentary and references for all data sources, so that results will be replicable in the future.

It was also pointed out that the authors used un-peer reviewed data sources for exploitation rates: Fishery Resource Analysis and Monitoring data (FRAM) for US fisheries, Spreadsheet Model (for Canadian marine sources) and the decay model (for Fraser River impacts, excluding Food, Social, Ceremonial (FSC) above Hell's Gate) (Simpson[1] et al. 1997, unpublished working paper). The group questioned how the three sources of exploitation (Canadian, US and in-river) were combined. (They can be summed directly because there is no overlap between them.)

There was considerable discussion about sources of bias and how it should be reported and/or analysed. The group suggested that the authors should document fixed values such as catch and release mortality rates used in exploitation rate models, as well as, sources of uncertainty in an appendix of the working paper, along with identifying the parameters most likely affected by the uncertainty, and a qualitative assessment of magnitude and direction of the effect. It was also suggested that the authors add a table of the same information to the database they have developed, and also add a table defining any constants that were included in the simulation models (e.g. assumed constants for different fishery gear types, etc.).

DISCUSSION & REVIEW OF WORKING PAPER (23-24 JANUARY 2014)

The Chair noted that additional work had been completed since the draft working paper was circulated to meeting participants. He also outlined the options the meeting participants had with respect to accepting, conditionally accepting or rejecting the working paper at the end of this process. At this point, it was recommended that the group review the TOR objectives and determine if the paper has sufficiently met them.

Objective 1: The authors are to include references to other work or data sources (e.g., integrated fisheries management plans, long-term periodic review from the Coho technical committee, etc.) to update the timetable originally presented in Appendix 5 of the IFCRT recovery strategy document. It was noted that this objective was only meant to provide context and was also intended to be kept brief.

[1] Simpson, K., R. Diewart, R. Kadowaki, C. Cross, and S. Lehmann. 1997. A 1996 update of assessment information for Strait of Georgia coho salmon stocks (including the Fraser River). Unpublished CSAP Working Paper.

Objective 2: This objective was partially met as presented in the draft working paper. Revisions are required with respect to confirming productivity calculations (removing hatchery influence from abundance), the brood year/return year time series alignments in some figures, Table 1 data updates, and additional details regarding methods used in data analysis.

With respect to analysis at the sub population level, the authors' understanding of this objective was "to provide *where reasonable/practicable…*" (e.g., individual estimates for subpopulation productivity do not currently exist). The authors should note in the working paper what elements are not possible or reasonable to expect, given the available data and time constraints.

Objective 3: This objective was met, with minor modifications. Two points were highlighted in Mike Bradford's review: include additional methods and commentary to outline how 2nd IFCRT recovery strategy objective can be quantified, and need to provide more commentary about productivity in relation to observed abundances (not meaningful to have one without knowing the other). The necessary productivity information is included in the working paper, but it needs to be linked more clearly/directly. Define what "current" population metrics actually are. The authors used the IFCRT long term objective of 40,000 Spawners as a surrogate for the long term objective of obtaining more than 1000 spawners in each subpopulation (and showed why it was reasonable to do so). This is one way to illustrate the stated objective, but there may be other ways. The original IFCRT Objective 2 is generally not quantifiable as written. It is more like a series of potential management actions. The authors selected elements of this objective that they felt could be quantified (but they should state explicitly which elements are being addressed, and why the others are not). Although top panel of Figure 5 in the working paper does address this issue, a revised figure was proposed: productivity on x-axis, harvest rates/exploitation on y-axis, with an isopleth following the replacement line.

Objective 4: Various issues were identified with the working paper's fulfillment of this objective.

Exploitation Rates: The group noted that the exploitation rates (ERs) reported in Table 1 should not be provided as deterministic values (need to include assessment of uncertainty). Although full analysis of uncertainty in ERs is beyond the scope of this process, the authors need to provide discussion about this subject in the revised working paper. The paper also does not contain sufficient description of how the ERs were derived. To resolve this, the authors could add a reference to the Coho pre-COSEWIC paper.

The group questioned how ERs had been allocated among different fishery types. A member of the committee noted that the distribution of fishery effort has changed over the years (due to regulation changes, changes in technology, etc.) which will have changed exploitation rates (and biases) over time. A further question arose about how uncertainty would be expected to change with different exploitation rates (constant, proportional, nonlinear, etc.). Similarly, how does the bias change? These are unknown at this time. It was also noted that uncertainty was not solely a function of uncertainty around er estimates and was bigger than that.

Sensitivity analysis: It was recommended that the authors generate a table or figure similar to Bradford et al. (1998) with isopleth following changes in abundance at different levels of exploitation, plotted on marine survival versus harvest rates. Slide 59 from the working paper presentation is a start towards this, but a table or figure would be more effective.

Objective 5: The group identified that changes or additions to the simulation analysis may change the recommendations and advice in the working paper, so could not be reviewed without seeing the revised analysis. This objective was not met in the draft working paper, and the group developed a proposed schedule to review a revised working document (outlined below). Meeting this objective will be subject to review of the advice resulting from assessment

of different stock recruit models and subsequent output from updated simulation models (based on best SR model results).

CLARIFICATION FROM FISHERIES MANAGEMENT

Chair sought clarification from Fisheries Management staff regarding the sufficiency of the working paper's conclusions and deadlines for required advice. If not sufficient, what additional information would be needed and by what date? Is the info provided in a form that is useful? If not, in what form is it needed? What is the drop-dead date?

FM staff indicated that they were most interested in answers to Objective 5 and answers to the questions surrounding additional analyses to be completed will hinge around this objective. The draft IFMP is due in early March. The advice generated by this process is required by approximately mid-February in order to be able to draft a discussion paper outlining the available options prior to completing the IFMP draft.

SUMMARY OF REQUIRED REVISIONS

1. Clarify the intended time frame of the working paper. Is it to be used for single or multi-year planning processes? This discussion is not intended to change the intent of the working paper, but to indicate that longer term projections must be considered as well as shorter term results, and how analyses and results are altered depending on the time frame being considered.
2. Publish model code and data, and explicitly state any fixed constants and assumptions used in the analysis (e.g. assumed mortality rates among different fishery types). Include equations used in models, rather than just references for models. Move extraneous results that were not ultimately used for advice into appendices. Include diagnostics about model performance. (Note: check for inconsistencies among results reported.)
3. Review data in Table 1. Make sure the data presented is consistent with the data used in the analyses. Document the sources of data and fully describe methods (and equations) used for various modeling approaches.
4. If used, clarify definition of "extirpation" used or use the term "pseudo-extinction". The authors should consider evaluating only against the long term and short term IFCRT objectives. It will not then be necessary to define or discuss risk of extirpation at all.
5. Discuss possibility of depensation or Allee effects.
6. Review time trends in productivity (recruits per spawner, R/S) versus spawners. First, the authors need to confirm time series have been calculated correctly (particularly with respect to hatchery contributions). If a pattern of "circling in" is evident, then the stock recruit model used is not appropriate. The authors need to consider alternative stock recruit models and choose most appropriate one for the data (i.e., Beverton-Holt, hockey stick and power model), showing the results and assessment of each model. Two productivity regimes are evident in the data, indicating that stock recruit analyses must be completed separately for each regime (or a dummy "regime" variable must be added to the models, similar to Bradford et al. (2000) analysis of Chilko Lake fertilization). The approach to modelling productivity will be different if a longer time frame is being considered (greater uncertainty in productivity) than a short term (more likely to be similar to current productivity). The figure also indicates a sudden shift in productivity (1990-91?). Currently, interior Fraser Coho Salmon appear to be staying in the low productivity regime, but for how long? It is likely that the next shift will be to a different regime, rather than back to a previous one. Researchers are searching for leading indicators of this type of shift, but none have been confirmed or reviewed at this time. Although Coho have a strict 3-year life history, there are no noticeably

different productivities among year classes. Differences in productivity are confounded by interannual differences in water heights. Variations in R/S will have greater impacts in high productivity years.

7. The group provided recommended revisions to the simulation models. A number of possible harvest rates to be investigated were proposed (current rate of 13-15%, approximately 20%, 40%, 60%, and contingent on brood strength and expected productivity), it was acknowledged that this would not be a trivial amount of work. In fact, a comprehensive assessment of harvest control rules could be the subject of a new request for advice. This process is trying to show the implications and potential risks to stocks resulting from different harvest rates, not developing what the actual harvest rates or rules should be. The group recommended that the authors revise their simulations to assess the probability of meeting short term and long term IFCRT (2006) objectives at a set of fixed exploitation rates (which are not synonymous with harvest control rules). Fishery Management staff will follow up with the authors to discuss the feasibility of developing "adaptive rules" for setting exploitation rates. The authors also need to provide an assessment of how well the simulation models perform (through retrospective analysis). Where possible, the authors should also conduct sensitivity analysis to demonstrate the impact of variations in parameters within their identified ranges.
8. The authors need to add discussion of implementation error and discuss its potential impact. Ideally, implementation error would be included as a term in the models, but there is currently not enough empirical information to model it accurately (i.e., there are currently no known bounds for it; it is unknown if it is random or biased; if it is biased, it is unknown if the bias is consistent at all levels of exploitation).
9. Additional appendices:
    - Table with parameter estimates, model results, list of assumptions and constants used in the models.
    - Table to summarize sources of bias, suspected direction of bias, qualitative assessment of possible magnitude of effect and potential implications resulting from it.
    - Simulation results that were conducted but not ultimately used to provide recommendations or advice should be moved to an appendix.
    - Produce a table similar to the one outlined below (or figure similar to Bradford 1998), via closed loop simulation and based on results from the most appropriate stock recruit model. One table assuming low productivity (1994-2012 return years), and one assuming average productivity (all years, 1978-2012 return years).

	LOW PRODUCTIVITY			
Total Exploitation	ST Obj 20K Spns	LT Obj 40K S in 1 gen	LT Obj 40K S in 3 gen	LT Obj 40K S in 5 gen
13%	*Probability of reaching obj (+/- range)*	*Probability of reaching obj (+/- range)*	*Probability of reaching obj (+/- range)*	*Probability of reaching obj (+/- range)*
16%	*Probability of reaching obj*	*Probability of reaching obj*	*Probability of reaching obj*	*Probability of reaching obj*

	LOW PRODUCTIVITY			
Total Exploitation	ST Obj 20K Spns	LT Obj 40K S in 1 gen	LT Obj 40K S in 3 gen	LT Obj 40K S in 5 gen
	(+/- range)	*(+/- range)*	*(+/- range)*	*(+/- range)*
20%	*Probability of reaching obj (+/- range)*	*Probability of reaching obj (+/- range)*	*Probability of reaching obj (+/- range)*	*Probability of reaching obj (+/- range)*
40%	*Probability of reaching obj (+/- range)*	*Probability of reaching obj (+/- range)*	*Probability of reaching obj (+/- range)*	*Probability of reaching obj (+/- range)*
60%	*Probability of reaching obj (+/- range)*	*Probability of reaching obj (+/- range)*	*Probability of reaching obj (+/- range)*	*Probability of reaching obj (+/- range)*

10. Provide additional discussion about elements identified in IFCRT Objective 2 (i.e., the productivity needed to maintain the identified recovery targets). Provide catch estimates for major fishery catch regions in recent years (available from FRAM), and discuss how fishing efforts have changed over time. Include discussion about potential freshwater habitat effects. Discuss data limitations (e.g., North & South Thompson data sets are not infilled, so are considered more reliable, but they are also most productive systems, which is not representative of other IFC CUs).

PROCESS TO REVIEW MANDATORY UPDATES TO WORKING PAPER

The group acknowledged that in order to accept the results of this working paper, a follow-up review would be necessary to assess critical modifications and additions to the stock recruit model assessments and simulation analysis sections of the paper.

The group agreed that a revised working document would be provided by February 7th followed by a virtual meeting on February 14th to discuss the updates. The revised paper will be posted to the CSAP ftp site and a notice will be sent to participants at that time. All participants are expected to provide review comments (by line number rather than through tracked changes in the document itself) to the CSAP office prior to February 14th. If consensus cannot be reached on February 14th, then the paper will be rejected.

A draft SAR will also be posted to the CSAP ftp site prior to February 14th to facilitate its development during the follow-up meeting.

SUBSEQUENT REVIEW OF REVISED WORKING PAPER (14 FEBRUARY 2014)

OVERVIEW

As outlined in the above section, a substantially revised working paper was distributed on February 11, 2014 via the CSAP ftp site. The review committee reconvened via web and teleconference on February 14th to discuss the revisions and subsequent conclusions and advice resulting from this process.

The Chair welcomed everyone back to this discussion and a round of introductions followed. The Chair commended the authors for the amount of work they accomplished in a short amount of time and thanked them for their efforts. Mary Thiess and Lynda Ritchie continued to rapporteur for this discussion. In all, 34 people participated in the follow-up session (Appendix F).

The Chair outlined the following objectives for this follow-up meeting:

1. Review the revised working paper:
    - Does revision satisfy major concerns identified during 23-24 Jan meeting?
    - Decide on acceptability of revision document
        - Accept as is
        - Accept with minor revisions
        - Reject
2. Review and reach consensus on key wording of conclusions and advice and other considerations in draft SAR.

Prior to the start of the review, the Chair also identified a minor housekeeping item. The authors used "conservation objectives" a number of times throughout the paper, but instead, should have used "recovery objectives". On lines 136-138 of the working paper, it says explicitly that "no conservation objectives exist". Furthermore, IFCRT 2006 refers only to "conservation strategy recovery objectives". The authors were advised to use consistent terminology throughout the research document.

PRESENTATION OF THE REVISED WORKING PAPER

The authors presented the revised working paper, highlighting the updates and changes that had been made since the conclusion of the meeting in January. These were summarized by way of tables, organized by section number from the working paper and cross-referenced to the terms of reference objective number the change related to. Participants were encouraged to ask questions and provide their comments at relevant points during the presentation.

Table 3. This table deals simultaneously with possible sources of bias and uncertainty, through a series of grouped columns in the table.

There was a suggestion that the contents of Table 3 should be more consistent with the accompanying text. The information in the table is purely qualitative and would benefit from data and/or references wherever possible to support the assertions. This is particularly of concern when describing exploitation uncertainty (for which there are many, possibly confounding sources of uncertainty and bias), working paper lines 777-797. The authors pointed out that they focused their summary on particular sources (namely, bias associated with under-reporting of catch mortality and errors associated with estimation of fishing effort). Participants argued that this bias might not be low, and also may not be consistent over the length of the time series.

The group discussed splitting the exploitation rate item in the table into two or more lines: release mortality, under-reported catch, change to mark selective fisheries, others. It was also noted that an exhaustive list of sources is not possible.

The authors should also change the possible bias direction to "negative" or "positive", instead of "low" and "high".

Line 798-799: Participants felt that the potential for seal predation on released fish was an issue in the past but has been reduced recently because of increased presence of killer whales. It

was also noted that this could become an issue again in the future (but cannot be quantified or predicted). It was recommended that the authors delete this sentence.

Productivity regimes. The group discussed the productivity regimes, and questioned how the occurrence of a high return in the low productivity regime could be differentiated from a low return in a higher productivity regime. Unfortunately, this will not be obvious. The boundaries between the two regimes are not clearly delineated.

Decision tables. The group appreciated the decision tables provided in the revised document (Tables 9a/b), but thought the results should be emphasized more (discussed further) in the commentary.

The group noted that the discussion focused more on the medium trend. A member of the group stated that even at 10% exploitation rate there is still a fairly high probability of not meeting the recovery targets. Because no term for implementation error was included in the model, the authors were encouraged to add discussion about implementation error to the working paper commentary. When uncertainty or implementation error is considered, the probabilities in Table 9 are likely upper estimates of the true probabilities and their distribution would likely be wider (i.e. the stated probabilities are likely biased high and there would be increased uncertainty around them). This is an important point for people interpreting the table to bear in mind.

The group discussed whether the probabilities in Table 9a/b should be re-stated in terms of risk (e.g., low probability of reaching recovery objective equals high risk; high probability of reaching recovery objective equals low risk). The authors were requested to check the labelling of Tables 9a/9b and Figures 21a/b. It needs to be clearly stated what the table contains. The group agreed that since the concept of risk is not universally understood, the tables should remain as they are (stating the probability of meeting a given objective), but with clear, consistent captions.

The authors confirmed that 2010-2012 geometric mean escapements were used to seed the simulation model. The group commented that using 2013 results would probably result in higher one generation probabilities, probably more like the two generation results.

The group noted that the model couldn't get above 40,000 spawners yet we are seeing 40,000 geometric mean spawners on the grounds this year. Authors responded by referring to the spaghetti plots in Figure 17. The Ricker stock-recruit model provides the best fit of average returns but there is obviously large variability around the modelled results. The group noted that the analysis puts a lot of confidence in the Ricker curve, there is a lot of variability, and only 3 generations are being simulated (i.e., not a very long time frame to reach equilibrium). It may not be a long enough time for the simulation. If the simulations were run over a longer period, higher abundances may be achievable. It was also noted that the box plots in Figure 21b show that it is possible to get above 40,000 spawners at least occasionally at low exploitation rates.

A member of the group questioned the worth of the recovery objectives if 40,000 spawners are nearing carrying capacity at the current productivity regime. The group was not ready to comment on carrying capacity with only one Ricker plot, but rather to assess the constraints of the model choice.

A member of the group noted that the hockey-stick stock-recruit model (Table 9b) provides no information about the recruit response relationship. Another member agreed that forcing the model to combine the two productivity regimes is not accurately modeling what is thought to be going on. The authors noted that this was a request from FM to use if it was unclear what the current productivity regime was. A member of the group appreciated that managers were looking for this information but emphasized that presenting it was a fallacy and is completely

uninformative. They further noted that it must be split up as there is no justification for modeling across two productivity regimes. Consensus of group was to leave Table 9b in as it was requested by management but ensure that the working paper and advisory report commentary captures the applicability of the results accurately.

The group agreed that the higher the exploitation rate, the greater the effort required around measuring escapement and exploitation rate.

Text Revisions:

- Page 27 (1107): Add bullet, page 27: disconnect exploitation comment from productivity comment ("regardless of exploitation, at this productivity level, there is low probability of exceeding 40,000 spawners")
- Line 1126: A member of the group questioned whether "Other Considerations" needed to be separate, or included with "Conclusions"? The group consensus was they could remain where they are (under a separate heading). Wild Salmon Policy benchmarks (distinct from management unit reference points) are coming and there is currently great uncertainty, though it is anticipated that Interior Fraser Coho will end up in the amber zone.
- Add precautionary comments in the research document about the hockey stick stock-recruit analysis. It is not valid (or informative) since its fit combines high and low productivity regimes.
- Remove Table 9b from the Science Advisory Report and add commentary to managers about utility of assessing probability of achieving greater than 40,000 spawners when in the low productivity regime (i.e., high probability is not possible). E.g. "while the future is uncertain, there is currently no evidence to suggest we have left the low productivity regime." and provide further recommendations on a course of action if productivity is suspected to have changed at some point in the future.
- Add recommendation to provide table for just low and just high productivity in future updates to this work (rather than low and low and high productivity combined).

The group spent the remainder of the scheduled meeting time reviewing and editing the wording of the draft SAR.

CONCLUSIONS

- The revised working paper presented on February 14th was accepted with minor revisions. A revised draft SAR will be distributed by February 21st. Other editorial revisions should be sent to the Chair who will forward to the authors by March 1st.
- Fisheries managers will get an approved, pre-published version of the SAR as soon as it is ready in order to meet their deadlines for the Integrated Fisheries Management Plan (March 3rd).

RECOMMENDATIONS & ADVICE

- The group proposed that a modelling group be formed to provide advice on appropriateness of available data, and other issues with modelling exercises that could use a structured decision making approach. This is not a trivial amount of work.
- Implementation error is recognized as a potentially large source of uncertainty. For example, if harvest is set at 20%, but actual exploitation is closer to 30%, what are the implications and how can this be assessed or monitored?
- If direction and bias of exploitation rate changes over time then results from this analysis may no longer apply. More work is required to obtain empirical information about

exploitation rate error so it can be included in future modelling efforts. (Also need to identify the type of work required to obtain this information).

ACKNOWLEDGEMENTS

The Chair thanks the authors of the Research Document for producing a valuable document in a timely fashion, the reviewers for conscientious evaluations, the meeting participants for constructive input, Mary Thiess and Lynda Ritchie for their excellent work as rapporteurs that resulted in these proceedings, and finally the CSAS office for assistance coordinating the meeting and producing final reports.

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Bradford, M. 1998. A risk assessment for Thompson River Coho Salmon. DFO Can. Sci. Advis. Sec. Res. Doc. 1998/092. 24p. Accessed August 19, 2014.

Bradford, M.J., Pyper, B., and Shortreed, K.S. 2000. Biological responses of sockeye salmon to the fertilization of Chilko Lake, a large lake in the interior of British Columbia. N. Am. J. Fish. Manage. 20(3): 661-671

Decker, A.S. and J.R. Irvine. 2013. Pre-COSEWIC Assessment of Interior Fraser Coho Salmon 1010 (*Oncorhynchus kisutch*). DFO Can. Sci. Advis. Sec. Res. Doc. 2013/121. x + 57 p. Accessed August 19, 2014.

Decker. A.S., Hawkshaw, M.A., Patten, B.A, Sawada, J, Jantz, A.L. 2014. Assessment of the Interior Fraser Coho Salmon (*Oncorhynchus kisutch*) Management Unit Relative to the 2006 Conservation Strategy Recovery Objectives. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/086. xi + 64 p.

Model Evaluation Workgroup (MEW). 2007. Fisheries Regulation Assessment Model (FRAM) An Overview for Coho and Chinook (Document prepared for the Council and its advisory entities.). Pacific Fishery Management Council. 7700 NE Ambassador Place. Suite 101. Portland, Oregon. 972200-1384.

Interior Fraser Coho Recovery Team (IFCRT). 2006. Conservation Strategy for Coho Salmon (*Oncorhynchus kisutch*), Interior Fraser River populations. Fisheries and Oceans Canada: xiii + 132 p.

APPENDIX A

TERMS OF REFERENCE

Assessment of the Interior Fraser River Coho Salmon Management Unit

Regional Peer Review Meeting - Pacific Region

January 23-24, and February 14, 2014
Nanaimo, British Columbia

Chairperson: Jim Irvine

CONTEXT

During the 1990s, declines in the abundance of southern British Columbia Coho Salmon populations prompted the DFO to implement a number of fishery management measures to significantly reduce the harvest of these stocks. In 2002, interior Fraser River Coho Salmon were designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as endangered (COSEWIC, 2002). In 2006 DFO published a conservation strategy outlining recovery objectives for interior Fraser River Coho.

Objective 1: The 3-year average escapement geometric mean in at least half of the sub-populations within each of the five populations is to exceed 1,000 wild-origin spawning Coho Salmon, excluding hatchery fish spawning in the wild. This represents a total Interior Fraser Coho spawning escapement of 20,000 to 25,000 wild-origin coho. This objective is designed to provide the abundance and diversity required to satisfy the recovery goal.

Objective 2: Maintain the productivity of Interior Fraser Coho so that recovery can be sustained. This objective is designed to ensure that the threats to recovery are addressed.

Recently, there have been improvements in escapements of southern British Columbia Coho Salmon. In addition, there is anticipation of increased salmon harvest opportunities for more abundant stocks and species, which could be constrained under the current measures to protect Coho Salmon that are intercepted in this fishery. These two factors have prompted a request from Fisheries Management Branch (FM), First Nations and client groups for science advice. They have requested that Science Branch conduct an assessment of the status of the populations that make up the Interior Fraser River (IFR) Coho Salmon management unit to determine what would be the impact on coho of increased sockeye harvest. To inform fishery planning and the development of the Integrated Fishery Management Plan (IFMP) for the 2014 season, science advice on the status of interior Fraser River Coho is required by January 2014.

This assessment will be developed in the context of the recovery objectives outlined in the 2006 Conservation Strategy (Interior Fraser Coho Recovery Team, 2006). A complete Wild Salmon Policy (WSP) status assessment is planned for the fall of 2014.

OBJECTIVES

The following working paper will be reviewed and provide the basis for discussion and advice on the specific objectives outlined below.

Decker, S., B.A. Patten, A.M. Tompkins, J. Sawada, T. Whitehouse, C. Parken. Assessment of the Interior Fraser River Coho Salmon Management Unit. CSAP Working Paper 2013-14/P64

The specific objectives of this RPR are to:

- Describe the fishery management actions have been taken since 2006 to meet the 2006 Conservation Strategy Recovery objectives.
- Quantify aggregate, population and sub-population metrics for abundance, distribution and productivity.
- Compare current population metrics to those outlined the 2006 Conservation Strategy recovery objectives.
- Quantify annual exploitation rates and the level of uncertainty in these estimates.
- Estimate the probability of achieving the 2006 Conservation Strategy Recovery objectives at a range of potential exploitation rates.

EXPECTED PUBLICATIONS

- CSAS Science Advisory Report
- CSAS Proceedings

PARTICIPATION

Participants will be invited from:

- DFO Science Branch
- DFO Fisheries Management Branch
- PSC Coho Technical Committee members
- Commercial and recreational fishing interests
- First Nations
- Non-government organizations
- Academia

REFERENCES CITED

COSEWIC. 2002. COSEWIC assessment and status report on the coho salmon Oncorhynchus kisutch (Interior Fraser population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 34 pp.

Interior Fraser Coho Recovery Team. 2006. Conservation Strategy for coho salmon (*Oncorhynchus kisutch*), interior Fraser River populations. Fisheries and Oceans Canada.

APPENDIX B

Regional Peer Review Meeting

Centre for Science Advice Pacific

AGENDA

Interior Fraser River Coho Assessment

January 23-24, 2014
Pacific Biological Station, Nanaimo, British Columbia

Chairperson: Jim Irvine

Thursday, January 23, 2014

9:00	Introductions • Review Agenda & Housekeeping • CSAS Overview and Procedures • Review Terms of Reference	Chair
9:30	Presentation of Working Paper	Authors
10:30	Break	
10:45	First review	Reviewer #1
11:15	Second review	Reviewer #2
12:00	Lunch	
1:00	General questions	Participants
2:30	Break	
2:45	Discussion & Review of Working Paper	Participants
4:00	Adjourn	

Friday, January 24, 2014

9:00	Welcome & Introductions	Chair
9:15	Recap of Day 1	Participants
9:45	Discussion & Review of Working Paper	
10:30	Break	
10:50	Discussion & Review of Working Paper	Participants
12:00	Lunch	
1:00	Forming Key Conclusions and Advice for Science Advisory Report	Participants
2:30	Break	
2:45	Finalizing Science Advisory Report	Participants
4:00	Adjourn	

APPENDIX C

Summary of Working Paper

Interior Fraser Coho is the name for the management unit (MU) which refers to the Coho Salmon (*Oncorhynchus kisutch*) that return to the Fraser River and tributaries upstream of Hells Gate in the Fraser Canyon. In response to low abundance of southern BC Coho Salmon stocks, fisheries that intercept Interior Fraser Coho have been restricted since 1998. This document describes the fishery management actions that have been taken since 2006 to meet the 2006 Conservation Strategy recovery objectives for Interior Fraser Coho, provides an assessment of current status of the MU against these objectives, quantifies annual exploitation rates and the level of uncertainty in these estimates, and provides estimates of the probability of achieving the 2006 Conservation Strategy Recovery Objectives at a range of potential exploitation rates.

Given that Wild Salmon Policy (WSP) benchmarks are not currently available for Interior Fraser Coho, the status of Interior Fraser Coho was assessed against two 'short term' and one 'long term' recovery objective originally proposed by the Interior Fraser Coho Recovery Team (IFCRT 2006). Short-term objective #1 consists of maintaining a minimum of 1,000 naturally spawning wild Coho Salmon (3-year geometric mean) in at least half of the 11 subpopulations that have been proposed within the five CUs (IFCRT 2006), while the long-term objective consists of maintaining 1,000 or more wild Coho Salmon in all 11 subpopulations. Our analyses showed that escapement levels of 20,000 and 40,000 spawners, respectively, would result in near 100% probability that these two objectives would be met. Generational average escapements for the Interior Fraser Coho aggregate exceeded 20,000 wild adults in every year from 2008 onward, but exceeded 40,000 wild adults in only the two most recent return years (2012 and 2013).

Short-term objective #2 focuses on maintaining the productivity of Interior Fraser Coho. After controlling for brood escapement, we found strong evidence for two distinct periods of productivity: a relatively high productivity period during 1978-1993 return years, and a low productivity period during 1994-2012. There is no evidence that Interior Fraser Coho have moved above the 'low' productivity' regime that has persisted since 1994 (return year).

Modelled estimates of exploitation rates averaged 10% during 1998-2012. From 1986-1997, average exploitation was nearly seven fold higher. The reliability of exploitation rate estimates for Interior Fraser Coho from 1998 onward is uncertain, owing primarily to uncertainty around the assumption that base period effort and exploitation rate (16-26 years ago) are representative of current effort and exploitation rate.

A model selection analysis indicated that the Ricker model best explained the stock-recruitment relationship for Interior Fraser Coho during the period of low productivity (1994-2012), and was used to form the basis of the harvest impact projections. Assuming low productivity, there is a strong trade-off between the probability of achieving the short-term objective of 20,000 spawners (3-year geometric mean) and exploitation rate. The probability of meeting the long-term objective of 40,000 spawners at low productivity is low regardless of exploitation rate. A declining population trend was predicted at exploitation rates exceeding 30%. Assuming a continuation of the 1994-2012 low productivity regime, there appears to be limited potential for recovering the management unit to abundance levels higher than 20,000-40,000 spawners. A relatively low escapement target within this range (20,000 spawners) could maximize harvest opportunities for other stocks while still maintaining Interior Fraser Coho at a relatively productive point along the stock-recruitment curve. However, this represents a riskier management strategy compared to a strategy of maximizing escapement given current productivity.

This assessment must be considered as preliminary and not equivalent to a Wild Salmon Policy status assessment since it relies primarily on the IFCRT recovery objectives and not formal WSP benchmarks.

APPENDIX D

Review of "Assessment of the Interior Fraser Coho Salmon Management Unit"
Pete Lawson
21 January 2013

The 2013 "Assessment of the Interior Fraser Coho Salmon Management Unit" is a solid document, based on a sound foundation, with most components having undergone several rounds of peer review. The organization is logical and writing is clear and understandable. From an editorial point of view there are no major issues.

The document reviews population delineations, and hatchery and harvest history. The principle data set, a time series of estimated spawner escapements and exploitation rates, is presented and updated. A variety of indicators of population status related to abundance, abundance trends, productivity, and distribution, is presented.

The underlying cause for concern stems from historically high harvest rates coupled with a drastic decline in marine survival from 15% in 1998 to 1% in 2007 (Beamish et al. 2010). Examination of the recruitment time series (Figure 3) suggests that the decline may have started as early as 1990. Delay in the response of the management system to the decline in marine survival led to several years of severe overharvest in the mid 1990s before fishery restrictions were implemented in 1998. In addition there were many years of harvest-driven spawner recruitment failure starting in 1980. Taken together this lead to extremely low spawner escapements in the 1990s. After fisheries were effectively curtailed in 1998 the stocks have been slow to recover and productivity is still stuttering. In four years, most recently 2010, spawners have failed to replace themselves, even in the absence of significant harvest. Based on the historical reconstruction there were no years prior to 1998 that stocks would have failed to replace themselves in the absence of harvest. Abundance since 1996 has shown a strong cyclical pattern with peaks in 2002 and 2012 and valleys in 1996 and 2005 (Figure 3, smoothed data).

This analysis is based on spawner surveys from 1975 to the present. Data qualtiy and coverage have improved over time, but data gaps present major challenges to deriving a consistent time series. The current data set is the result of much analysis, adjustment, and in-filling of missing data. Given the attention that has been paid to constructing this data set it must be taken as best available data. It is, however, worrisome that 20 – 25% of escapement prior to 1998 is estimated as a ratio based on more recent years. Given the moderate to low r^2 of these relationships they are little better than random variation around a mean. This also assumes that the relationship between escapements in the in-filled CUs (Lower Thompson, Mid/Upper Fraser, and Fraser Canyon) and the reference CUs (South and North Thompson) has been stationary. I have no way to evaluate this assumption. Although the general patterns over time are robust and consistent with other observation, I have concern that finer scale (CU and Population) data may not accurately reflect fine-scale patterns. This makes it harder to interpret statistics derived at these scales (e.g., annual productivity, variability). Good estimates of variability are important for the analysis of conservation impacts.

The exploitation rate analysis considers a variety of models and analytical techniques, and the discussion shows a good understanding of the pros, cons, and biases of the different methods. Results from the closed loop analysis using time series-derived parameters seem to be most consistent with our understanding of these systems and therefore is the most appropriate basis for conclusions. The resulting advice, that a 30% harvest rate is sustainable but should be adjusted depending on marine survival regime, is the reasonable conclusion from this analysis. Exploitation rates of 30% are considerably higher than those in the past 15 years, and the

potential consequences of this higher harvest level include the extirpation of weaker populations within the Interior Fraser. The degree of risk needs to be considered before advising a higher exploitation rate.

The analysis presented here assumes stationary freshwater production. However, there is documentation of a range of threats to salmon habitat in the Fraser River. Chief among these are habitat impacts in freshwater and estuaries and invasive species (Decker and Irvine 2013). On the marine side Beamish et al. (2010) tie marine survival in the Strait of Georgia with temperature. Temperature has risen and is projected to continue increasing. Rising temperatures also may affect freshwater survival as shown for Oregon coastal Coho Salmon (Lawson et al. 2004).

This analysis makes a case that strong regimes will continue to drive a cyclical pattern of survival for Upper Fraser Coho Salmon. If, in addition, there is a more general downward trend in freshwater productivity, marine survival, or both, then conservation problems will continue to worsen. A decrease in exploitation rates can lead to short-term recoveries in escapement levels, but cannot compensate for longer-term trends (Lawson 1993). In addition, we are currently in a relatively favorable regime for salmon survival: the Pacific Decadal Oscillation has been consistently negative since 2008. Recommendations based on current conditions and short-term (3 generation) trends should be tempered with the expectation of a cyclical downward swing in survival.

In summary, the authors present a thorough, well considered and executed analysis of the current status of Interior Fraser Coho Salmon. They have based their analysis on a solid foundation of peer reviewed work and best available data. Beyond this, they have considered the major limitations to the various data sets and techniques employed, and have attempted to address them in their analysis. Comparison of results with other related systems helps strengthen conclusions. Perhaps the most important assumption of this work is that productivity of the Interior Fraser MU, and relative productivity of the CUs within it, have remained constant over the time period of analysis. An ancillary assumption in their recommendations is that mean productivity and marine survival will not change in the near future. Application of their analysis should include consideration of outside information regarding these assumptions.

Citations

Beamish, R.J., R.M. Sweeting, K.L. Lang, D.J. Noakes, D. Preikshot, and C.M. Neville. 2010. Early marine survival of coho slamon in the Strait of Georgia declines to very low levels. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, 2:1, 424-439.

Decker, A.S. and J.R. Irvine. 2013. Pre-COSEWIC Assessment of Interior Fraser Coho Salmon (*Oncorhynchus kisutch*). DFO Can. Sci. Advis. Sec. Res. Doc 2013/121. x + 57 p.

Lawson, P.W. 1993. Cycles in ocean productivity, trends in habitat quality, and the restoration of salmon runs in Oregon. Fisheries (Bethesda) 18(8): 6-10.

Lawson, P.W., E.A. Logerwell, N.J. Mantua, R.C. Francis, and V.N. Agostini. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest Coho Salmon (*Oncorhynchus kisutch*). Can. J. Fish. Aquat. Sci.61: 360-373.

APPENDIX E

Review of Assessment of Interior Fraser Coho **Decker et al.**

By Mike Bradford

In this review of the status of Interior Fraser River Coho Salmon, the authors were tasked with the following five objectives:

1. Describe the fishery management actions that have been taken since 2006 to meet the 2006 Conservation Strategy recovery objectives.
2. Quantify aggregate, population and subpopulation metrics for abundance, distribution and productivity.
3. Compare current population metrics to those outlined the 2006 Conservation Strategy recovery objectives.
4. Quantify annual exploitation rates and the level of uncertainty in these estimates.
5. Estimate the probability of achieving the 2006 Conservation Strategy Recovery Objectives at a range of potential exploitation rates.

In general the report is well written and the authors are commended for assembling this report in a very short time frame. The authors, however, have not explicitly addressed all of their objectives. In this review I focus on the main points that may assist the development of the Science Advice from this paper.

Management Actions since 2006

There is not an explicit or detailed section that describes management measures since 2006 (some information is provided in section 1.1.3). Perhaps a timeline along the lines of Appendix 5 of the recovery plan would be more useful in identifying the changes to fishery patterns that have taken place, and the IF coho conservation measures.

Evaluation of Recovery Objectives

Major Point: In my view an analysis of the status of IF coho under the IFCRT (2006) should incorporate Objectives 1 and 2 of the Plan (see text below). Objective 2 was specifically written to caution against conclusions of recovery in cases where abundance alone had increased to meet Objective 1 without considering the role of changes in productivity as well as other threats on the sustainability of the aggregate. Although quantitative targets were not provided for the second objective, at a minimum there should be a qualitative assessment and possibly suggestions regarding productivity objectives.

The following is the text from the Conservation Plan for IF Coho for the first 2 recovery objectives:

3.3 Recovery Objectives

The following two objectives need to be achieved in order for Interior Fraser Coho to be considered to have met the recovery goal.

OBJECTIVE 1: The 3-year average escapement in at least half of the sub-populations within each of the five populations is to exceed 1,000 naturally spawning Coho Salmon, excluding hatchery fish spawning in the wild. This objective is designed to provide the abundance and diversity required to satisfy the recovery goal.

OBJECTIVE 2: Maintain the productivity of Interior Fraser Coho so that recovery can be sustained. This objective is designed to ensure that the threats to recovery are addressed.

This objective may be met by addressing the causes for the decline that were identified by COSEWIC as follows:

- Development of a harvest management plan to ensure that exploitation rates are appropriate to changes in productivity caused, for example, by fluctuations in ocean conditions.
- Identification, protection, and, if necessary, rehabilitation of important habitats.
- Ensure that the use of fish culture methods is consistent with the recovery goal.

Exploitation Rates

The authors were tasked with quantifying exploitation rates and their uncertainty, and a brief description of the methodologies for estimating exploitation rates was provided. It is noted there are likely considerable uncertainties but few details are provided. In the conclusion section it is stated the exploitation rates are "likely biased" but there is no analysis to support this conclusion.

The critical issue for the exploitation rates is whether they are significantly biased low, such that an increase in exposure to fisheries may result in underestimated mortality. It would be useful to know the distribution of mortalities among fisheries, to understand which fisheries may warrant further refinement of mortality rate estimation procedures.

I am aware of a number of new studies on release mortality for Coho Salmon from various fisheries and a review of newer information may also be warranted.

Major Point: Perhaps a conclusion of the exploitation rate section is that a full analysis of the bias and uncertainty in exploitation rates is not possible under the current time frame. It would be useful if the authors could provide recommendations on how to proceed. If information on the fisheries that are likely to be the source of potential increases in mortality were available, that could direct more detailed studies.

Evaluation of management scenarios

The authors have proposed the use of Ricker stock-recruit relation, fitted by a variety of means, to evaluate exploitation rate scenarios for IF coho. Most of the advice is generated using long-term scenarios in closed loop simulations. The description of the methods is brief and it makes the results difficult to evaluate. For example modelling "extinction" is not straightforward and many assumptions are normally made for such an analysis. The authors did not explicitly address the relation between exploitation rate and the probability of meeting the IFCRT recovery goals.

In my opinion this approach is <u>not</u> appropriate for providing management advice under recent survival scenarios. My reasons for this are as follows:

Major Point: There is ample evidence to suggest that the Ricker SR model is not appropriate for Coho Salmon as there is no evidence that the density-dependent mechanisms (which occur in freshwater) lead to declining smolt production at high abundance. Although it is common practise to use the Ricker model, and there is significant experience with the mathematics of parameter estimation, its use must be justified on the basis of the available evidence, or, it must be shown that its use over biologically preferred models will not unduly bias the results. Asymptotic models, such as the Beverton-Holt form or the Hockey-Stick appear more

appropriate for describing the density-dependent segments of coho life cycle for small streams. For coho aggregates in large watersheds, density-dependent habitat use may occur (juveniles dispersing to downstream habitats) and a power model may better represent the dynamics. When the Ricker model is fit to data generated by the power model productivity is usually overestimated, and Smsy is underestimated (compounding the other sources of bias noted by the authors).

At a minimum the authors should plot the empirical data so that the reader can evaluate the model's description of the data.

Major Point: The SR model is a statistical representation of average conditions over the time period for the data used. Management parameters such as u and Smsy are based on average conditions. Unfortunately when survival rates have a time-series component, such as serial trends or shifts between regimes, large bias in the parameter estimates can occur resulting from the confounding of trends in survival, and the estimation of density-dependent processes. To some degree these can be resolved by the 2-stage modelling process. Secondly, management parameters from SR relation are unresponsive to short-term trends in productivity and can be misleading when downward trends begin to occur. A review of science advice and management responses for IF coho from the early 1990s supports this view (see Rice et al. 1994 PSARC report, Can. Man. Rept. Fish. Aquat. Sci. 2318 p 185). During this period productivity rates changed rapidly and the advice generated by SR data lagged the environmental change; that may have led to an under appreciation of the changes in harvest that were actually required to maintain spawning abundance.

Major Point: Since the decline in abundance in the 1990s there have been 2 stanzas of increased productivity, the first of which was short-lived, lasting only a few years; the second has occurred in the last few years. These autocorrelated trends in harvest were the reason that recovery objective #2 included "Development of a harvest management plan to ensure that exploitation rates are appropriate to changes in productivity caused, for example, by fluctuations in ocean conditions."

As noted one of the paper's objective was to "Estimate the probability of achieving the 2006 Conservation Strategy Recovery Objectives at a range of potential exploitation rates." The strong link between smolt-adult survival rates and sustainable exploitation rates suggests, and the autocorrelation in smolt-adult survival suggests that takes advantage of recent years estimates of smolt-adult survival or productivity to generate a forecast model that would predict the probability of reaching the numerical goal of Objective 1 under different exploitation rate scenarios. Using the historical data it should be straightforward to estimate the skill of different forecast models (and data sources) at predicting productivity and returns. Figure 21 of the recovery plan provides a basis for such a model.

Comments on Conclusions and Advice (comments by paragraph).

1. Since the short-term objective from the IFCRT consists of 2 sub-objectives, the conclusion of status should compare both abundance and productivity.
2. The initial statement that the exploitation rates are biased (high or low?) is not supported by the paper. More analysis will be required to evaluate the reliability of the estimates, especially if changes to fishery patterns are proposed. Advice that could be proposed would be a more detailed analysis.
3. The recommendation for a specific model for the SR analysis is not supported by a formal analysis, especially with alternative model forms, or much simpler approaches that do not use stock-recruit methodologies.

4. There is no analysis to relevant to the objective of the paper to evaluate performance relative to the IFCRT recovery objectives. As noted the simulation findings are reliant on modelling the patterns in productivity, but there is no analysis to show that the modelled survival rates resemble the observed data. It is impossible to predict the future- a simulation study of alternative management systems that are responsive to future events would probably be more useful that simulating the future (and a static exploitation regime) based on the replication of recent past events.
5. It is suggested that escapement data are the "only" data to assess status and performance, however but that ignores the potential utility of wild smolt indicator programs, explicit estimates of harvest and non-retention mortality and other sources of information that could provide an efficient management regime. None of these considerations are included in the paper and it is hard to reconcile this advice with the absence of analysis.

APPENDIX F

Meeting Participants

Name	Affiliation	Jan 23	Jan 24	Feb 14
Ashton, Chris	Commercial Salmon Advisory Board	X	X	
Bailey, Richard	DFO-Science	X	X	X
Baillie, Steve	DFO-Science			X
Bradford, Mike	DFO-Science	X	X	X
Decker, Scott	DFO-Science	X	X	X
Desy, Travis	DFO-Science			X
Fraser, Kathy	DFO-Science	X	X	
Grant, Sue	DFO-Science	X		
Grout, Jeff	DFO-FAM	X	X	X
Hawkshaw, Mike	Contractor (author)	X	X	X
Hill, Aaron	Marine Conservation Caucus	X	X	
Holt, Carrie	DFO-Science	X		X
Irvine, Jim	DFO-Science	X	X	X
Jantz, Les	DFO-FAM	X	X	
Kadowaki, Ron	DFO-FAM	X	X	X
Komick, Nick	DFO-Science	X	X	
Kronlund, Rob	DFO-CSAP	X	X	X
Lawson, Pete	National Marine Fisheries Service	X	X	X
LePage, Stuart	DFO-Science			X
Leudke, Wilf	DFO-Science	X	X	X
Lynch, Cheryl	DFO-SEP	X	X	
MacDougall, Lesley	DFO-CSAP	X	X	X
Maxwell, Marla	DFO-FAM	X	X	X

Name	Affiliation	Jan 23	Jan 24	Feb 14
Maynard, Jeremy	Sport Fishery Advisory Board	X	X	X
McGrath, Elinor	Okanagan Nation Alliance	X	X	X
Nener, Jennifer	DFO-FAM	X	X	X
Nicklin, Pete	Upper Fraser Fisheries Conservation Alliance	X		X
O'Brien, Dave	DFO-Science	X	X	X
Parken, Chuck	DFO-Science	X	X	X
Patten, Bruce	DFO-Science	X	X	X
Rankis, Andy	Northwest Indian Fisheries Commission	X	X	
Riddell, Brian	Pacific Salmon Foundation	X	X	
Ritchie, Lynda	DFO-Science	X	X	X
Sawada, Joel	DFO-Science	X	X	X
Schweigert, Jake	DFO-Science	X	X	
Scroggie, Jamie	DFO-FAM	X	X	X
Staley, Mike	Fraser River Aboriginal Fisheries Secretariat	X	X	X
Thiess, Mary	DFO-Science	X	X	X
Tompkins, Arlene	DFO-Science	X	X	X
Trudel, Marc	DFO-Science	X		
Van Will, Pieter	DFO-Science	X	X	
Wall, Adrian	DFO-Science			X
Walsh, Michelle	Secwepemc Fisheries Commission	X	X	X
Welsh, Paul	DFO-Science			X
Whitehouse, Timber	DFO-Science	X	X	
Willis, Dave	DFO-SEP	X		
Wright, Howie	Okanagan Nation Alliance	X	X	X